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MATERIAL DISTRIBUTION IN ELECTRICAL FUSES USING ARHENIUS' EQUATIONS

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Abstract: In this paper the evolution of material loss belonging to an automated fuse, which is subjected to a short-circuit regime based on SR EN 60947-2 standard with 2-3 times the value of the nominal current is shown. The obtained results have been collected within 11.05.2018 and the end of the year.
Key words: Arhenius , aging , material loss, standard, short-circuit.

1. INTRODUCTION

The negative phenomenon which appear in automated fuses lead to unwanted effects on the quality of electrical energy and on the fuse.

The unwanted phenomenon is called electrical -erosion which assumes the surrender of electrons between anode and cathode, this consists of material surrender, which appear due to following causes of the weakened electrical contact.

In figure 1 a thermographing of the electrical contact is represented, as can be seen there are zones where we have a medium temperature from 22 C to 35,7 C, this phenomenon appears due to weakened electrical contacts which affect the good function of this.

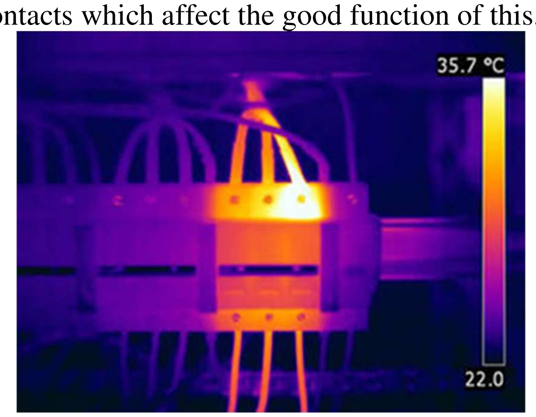

Fig. 1. Termographing an electrical panel [3]

2. TESTING METHODOLOGY

A testing methodology to determine the accelerated aging of the material used in automated fuses has been defined and implemented in software. The following logical scheme for the program from Fig. 4 has been devised.

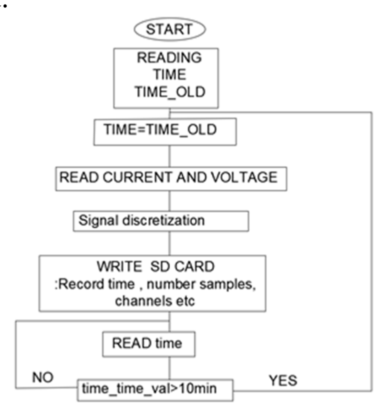

Fig. 2. Logical schematic of the implementation for the data acquisition application

3. PRACTICAL EXPERIMENT

Based on the testing methodology, a practical experiment using a microcontroller for acquisition of the signals has been set up.

In Figure 2 the electrical schematic of the practical implementation is shown. This is used to acquire the voltage, current and temperature which take place during the short circuit regime which loads the automated fuse. The standard used to carry out the practical experiment is SR EN 60947-2.

In figure 3 the electrical schematic of the circuit is depicted while in figure 4 the practical experiment for the acquisition of the current, voltage and temperature signals is represented.

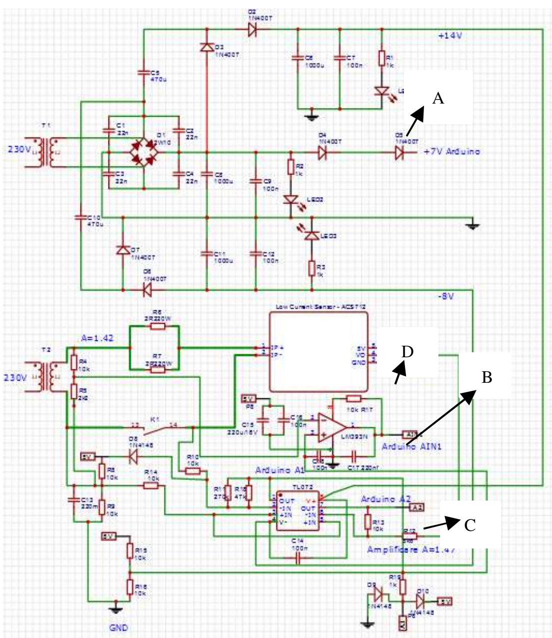

Fig. 3a. Electrical schematic

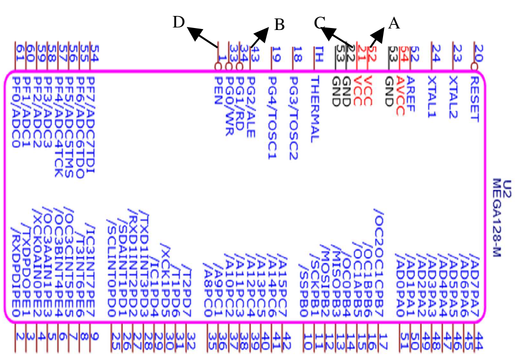

Fig. 3b. Electrical schematic

Figure 5 presents the practical implementation carried out with the C++ programming language which has been used to acquire the currents, voltages and temperature and store them on the SD card.

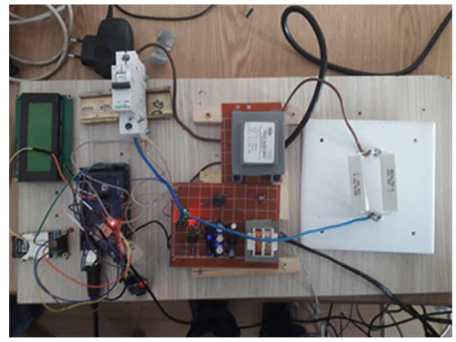

Fig. 4. Practical implementation

```
#include <arduino.h>

#define ledPin 13 // se defineste pinul 13
//#include <avr/pgmspace.h>
#define LOG_2_FFT  7
#define FFT_SIZE 128 // Numar de esantionare
#define MIRROR FFT_SIZE / 2
#define NWAVE 256 // Longitunidea undei sinusoidala
#define NBINS 8 // Numarul de intervale +1
#define IND_STEP FFT_SIZE / (2 * NBINS) // Indexare matrice

const uint8_t bar_Width= 7;
const uint8_t updt_Rate = 16;
      uint8_t updt_Cntr=0;

volatile uint16_t smpl_Time = 2475;//156 500 micro=32
//2250 =35 2275=35  2400=33 2450=32

//volatile uint16_t smpl_Time = 16000;
volatile uint16_t smpl_Nmbr = 0; // Exemplu conter.
volatile uint16_t smpl_Nmbr_vechi = 0;
volatile int16_t adc_Offst = 0;
volatile uint32_t cntr_TmrF = 0; // contor de timp.
uint32_t avrg_TmrF = 0; // valorea medie N = updt_Rate masurata.

volatile int16_t xu_r[FFT_SIZE]; // 256 Bytes
volatile int16_t xi_r[FFT_SIZE]; // 256 Bytes
```

Fig. 5. Practical implementation of the program

3. RESULTS

The data has been acquired during the period 11.05.2018 to 31.12.2018 with a sample size of 10 min which has been sent on 2 buffers.

In table 1 the evolution of Arhenius has been presented on basis of the acquired measurements.

Table 1 Arhenius' evolution

Period	Temperature K	1/T	ln k
11-18.05	299,04	0,00334	16,846
4-11.06	300,58	0,00333	16,8505
20-27.06	299,05	0,00334	16,8454
28-5.07	298,58	0,00335	16,8439
30-6.08	300,95	0,00332	16,8518
9-16.09	301,94	0,00331	16,8886
17-24.09	301,96	0,00331	16,9055
25-2.10	301,99	0,00331	16,9224
3-10.10	302,02	0,00331	16,9393

11-18.10	302,05	0,00331	16,9562
19-26.10	302,08	0,00331	16,9732
27-4.11	302,11	0,00331	16,9902
22-29.11	302,2	0,00331	17,0412
30.-7.12	302,22	0,00331	17,0582
16-23.12	302,28	0,00331	17,0924
24-31.12	302,31	0,00331	17,1095

Figure 6 indicates the material loss between anode and cathode due to temperature.

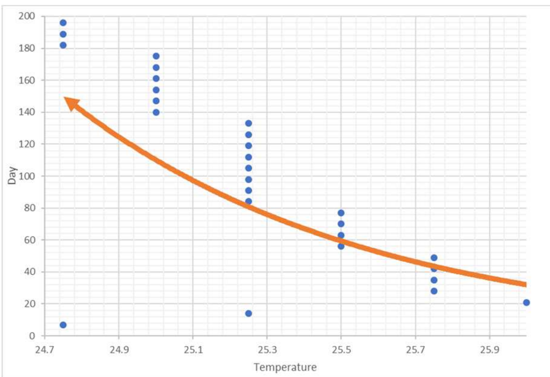

Fig. 6. Dependency of material loss due to temperature

In case of the measurements, the Arhenius equations regarding material loss [4] has been used

$$k = Ae^{\frac{-E_a}{RT}} \quad (1.1)$$

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where **k** is the rate constant $\mathbf{E_a}$ is the activation energy, $\mathbf{R = 8.314\ J{\cdot}mol^{-1}K^{-1}}$ is the molar gas constant, **T** is the temperature, and **A** is called the **pre-exponential factor** or the **frequency factor**

$$\mathrm{Ln}(k)=\ln(A)-\frac{-E_a}{RT} \quad (1.2)$$

$$ln(k) = \frac{-E_a}{R}\left(\frac{1}{T}\right) + ln\ (A) \quad (1.3)$$

Figure 7 represents the activation energy of used materials, in which the defect rate of material si shown, as well as the phenomenon of material surrender according to the Arhenius equation using the calculation formula 1.3.

In figure 7 the activation energy relative to time is represented. As can be observed we have a tendency to increase which is directly proportional with the temperature and an increase in material surrender with a value of and 1.78% .

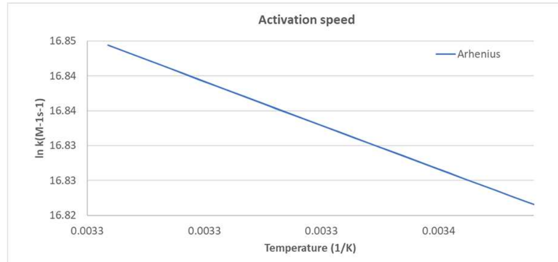

Fig. 7. Activation energy

In table 2 the acquired measurements are depicted with a mean results for 1 week.

Table 2 Evolution of carried measurements

Period	Temperature (°C)	Voltage (V)	Current (A)
11-18.05	25,89	0,003	4,864
19-26.05	26,06	0,003	4,870
20 -27.06	25,90	0,004	4,867
28 -5.07	25,43	0,004	4,871
7-14.08	29,00	0,004	4,833
9-16.09	28,79	0,004	4,844
17-24.09	28,81	0,004	4,841
3 -10.10	28,87	0,004	4,841
19-26.10	28,93	0,004	4,836
27-4.11	28,96	0,004	4,834
5-13.11	28,99	0,004	4,829
14-21.11	29,02	0,004	4,834
16-23.12	29,13	0,004	4,829
24-31.12	29,16	0,004	4,827

Figure 8 represents the temperature evolution as a function of current during the time frame.

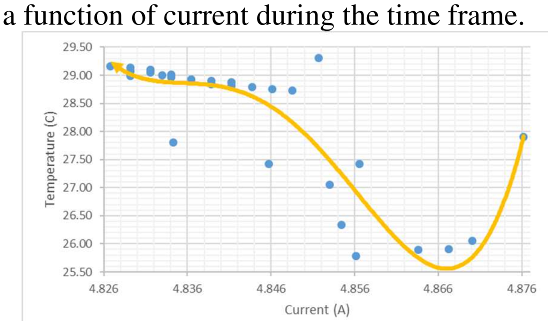

Fig. 8. Evolution of temperature as a function of the current

Figure 9 represents the evolution of the voltage as a function of the current having an increase tendency with the current of constant voltage.

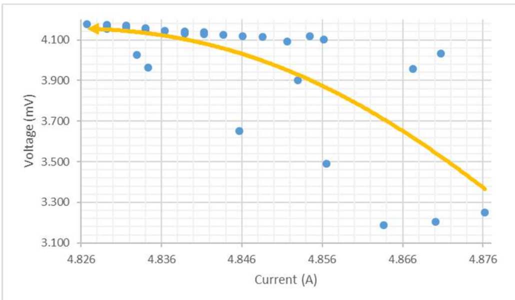

Fig. 9. Evolution of voltage as a function of the current

Figure 10 represents the evolution of the natural logarithmic curve of the current as a function of the voltage, which shows an increase tendency over the time period. The voltage has a tendency to increase. According to the practical experiment a decrease of the current to a constant value has been observed.

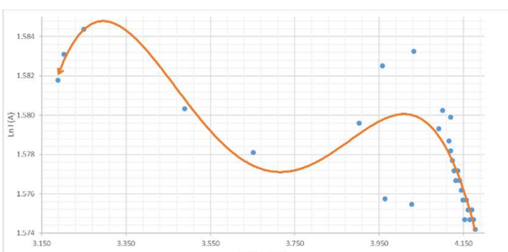

Fig. 10. Evolution of the current as a function of voltage

4. CONCLUSION

Based on the obtained results we have the following conclusions:

1) According to the standard SR EN 60947-2, the short circuit regime uses currents with values from 1.5 In to 3 In
2) The measurements have been made on a period of 150 consecutive days, with a sample of 10 min and all the data has been stored on a SD card
3) According to Arhenius' law, the reduction in material is about 1.78 % from its total weight
4) The current rises proportionally with the temperature of the external environment

5. REFERENCES

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[3] https://999.md/ro/64184736

[4] http://xaktly.com/Arrhenius.html

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Distribuția de materiale în siguranțe electrice utilizând ecuațiile lui Arhenius

În această lucrare se prezintă evoluția pierderilor de material pe baza rezultatelor practice obținute în intervalului 11.05.2018 - finalul anului 2018, perioadă în care disjunctorul electric a fost supus unui regim de scurtcircuit, cu respectarea normativul SR EN 60947-2, suportând de 2-3 ori valoarea curentului nominal.

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